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Geology of

Carbonatite – Alkalic Rock Complexes in Ontario:

James Bay Lowlands

Districts of Cochrane and Kenora

by R.P. Sage

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Foreword

As part of the alkalic rock – carbonatite project begun in 1974, an economic evaluation of known and inferred alkalic rock - carbonatite complexes in the James Bay Lowlands was undertaken in 1979. Recommendations made from this study resulted in the discovery of the Martison Lake residual apatite and niobium deposits in 1980.

V.G. Milne
Director
Ontario Geological Survey

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CONVERSION FROM SI TO IMPERIAL			CONVERSION FROM IMPERIAL TO SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note. Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

GEOLOGY OF CARBONATITE – ALKALIC ROCK COMPLEXES IN ONTARIO

James Bay Lowlands

DISTRICTS OF COCHRANE AND KENORA

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Manuscript approved for publication, January 27, 1983, by John Wood, Chief Geologist, Ontario Geological Survey. This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

Approximately 14 pronounced aeromagnetic anomalies, which are thought to reflect the presence of discrete intrusions, occur beneath or partly beneath Paleozoic cover rocks of the James Bay Lowlands. Most of these anomalies have never been drill tested. Limited diamond drilling has shown that three anomalies are caused by mafic (gabbro) intrusions (Squirrel River, Mammamattawa, Drowning River), one is caused by a carbonatite intrusion (Albany Forks), and one anomaly is caused by a syenite complex consisting of two intrusive subcenters (Nagagami River, described in a separate report). Drilling at Martison Lake suggests the presence of a carbonatite intrusion. A cluster of aeromagnetic anomalies north of Hearst, Ontario, has a west of north trend. Precambrian structures controlling this cluster are unknown and structural control for the more scattered anomalies is unknown.

The Albany Forks Carbonatite Complex contains a high concentration of magnetite which could be a valuable by-product of any mining operation, if other mineralization can be located.

The Martison Lake anomaly warrants examination for the presence of a residual accumulation of apatite and magnetite, similar to that in the Cargill Township carbonatite complex.

RESUME

On signale près de 14 anomalies aéromagnétiques très accentuées, dont l'on pense qu'elles révèlent la présence d'intrusions discrètes, partiellement ou entièrement enfouies sous les roches de couverture paléozoiques des basses-terres de la baie James. La plupart de ces anomalies n'ont jamais été soumises au test du sondage. Quelques forages au diamant ont révélé que trois anomalies (celles de la rivière Squirrel, de Mammamattawa et de la rivière Drowning) proviennent d'intrusions mafiques (gabbro), que l'une résulte d'une intrusion de carbonatite (celle d'Albany Forks), et qu'une autre anomalie est imputable à un complexe de syénite formé de deux sous-centres intrusifs (celle de la rivière Nagagami, décrite dans un rapport distinct). Le forage effectué au lac Martison révèle la présence d'une intrusion de carbonatite. Un ensemble d'anomalies aéromagnétiques situé au nord de Hearst (Ontario) tend vers le nord-ouest. On ne connaît pas les structures précambriennes contrôlant cet ensemble, pas plus qu'on ne sait en quoi consiste le contrôle structural des anomalies les plus dispersées.

Le complexe de carbonatite d'Albany Forks contient une forte concentration de magnétite qui peut s'avérer un précieux sous-produit d'exploitation minière, si l'on peut trouver d'autres traces de minéralisation.

L'anomalie du lac Martison justifie la recherche de traces d'accumulation résiduelle d'apatite et de magnétite, semblables à celle du complexe de carbonatite du canton de Cargill.

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Introduction

As part of the alkalic rock – carbonatite project, a brief examination was made of existing data concerning aeromagnetic anomalies that result from sources lying beneath muskeg and Paleozoic rocks of the James Bay Lowlands (Figures 1 and 2). Of the 14 anomalies previously interpreted by Satterly (1970) as possible alkalic rock or carbonatite intrusions, three have been identified as gabbro, one as syenite, one as carbonatite, and one tentatively as carbonatite. The remaining eight anomalies have yet to be identified. Inaccessibility, depth of burial, and impediments to drilling have inhibited work on the intrusions. All of the anomalies warrant additional prospecting for mineral commodities associated with rocks of each respective suite. The Nagagami River alkalic rock complex is described in a separate report (Sage 1983). All thin sections and samples described in this report are stored at the Royal Ontario Museum, Toronto.

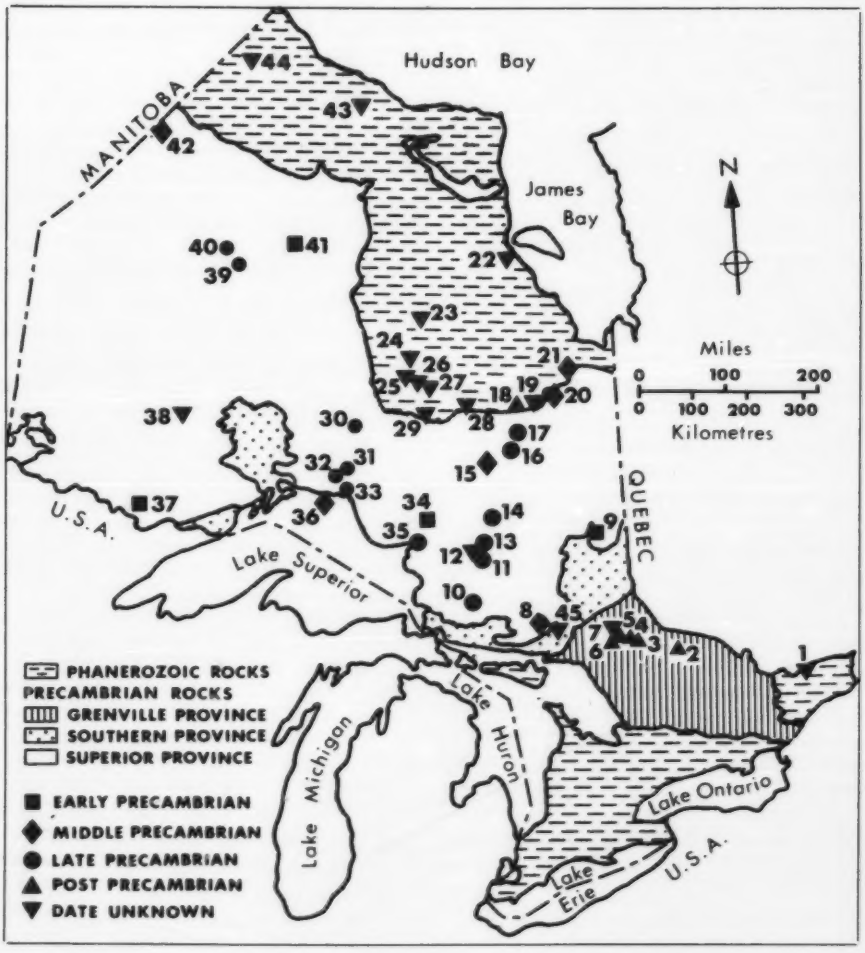

Figure 1. *Key map showing location of carbonatite – alkalic rock complexes in Ontario. Also shown are mafic complexes in the James Bay Lowlands*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. *Borden L.*
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. *Cargill Tp.*
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. *Valentine Tp.*
20. *Goldray*
21. *Argor*
22. ***Lawashi R.***
23. ***Poplar R.***
24. ***Albany Forks***
25. ***L. Drowning R. & Drowning R. (mafic)***
26. ***Kingfisher R. W.***
27. ***Kingfisher R. E., Mammamattawa (mafic), & Squirrel R. (mafic)***
28. ***Martison L.***
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. *Killala L.*
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Poohbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. ***Gooseberry Br.***
44. ***Niskibi L.***
45. *Nemag L. & Lusk L.*

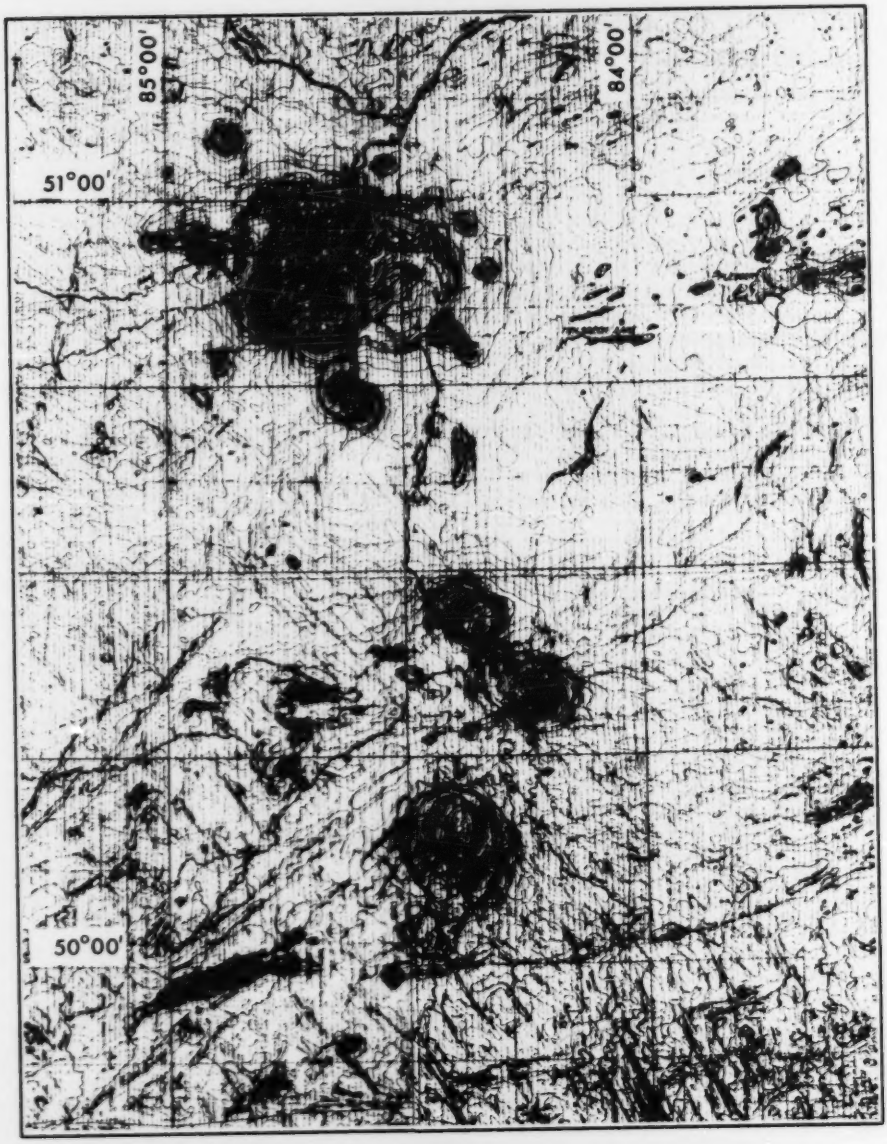

Figure 2. Aeromagnetic map of anomalies north of Hearst (ODM-GSC 1970).

Anomalies Untested by Diamond Drilling

MARTISON LAKE ANOMALY

Location and Access

The Martison Lake occurrence is located at approximately 50°15'N Latitude and 83°15'W Longitude approximately 80 km northeast of Hearst, Ontario.

Previous Work

A brief mention of the occurrence was made by Ferguson (1971).

GENERAL GEOLOGY

One diamond drill hole encountered magnetite and phosphate-rich sand, but failed to reach bedrock. On the basis of this drill hole, the aeromagnetic anomaly is probably caused by a carbonatite intrusion.

GEOPHYSICS

The Martison Lake occurrence consists of two circular aeromagnetic anomalies with centres approximately 2.4 km apart (aeromagnetic map 3860G, ODM-GSC 1967) (Figure 3). The south anomaly is 2.0 km in diameter and the north anomaly is 4.0 km in diameter. The one drill test was located on the south anomaly.

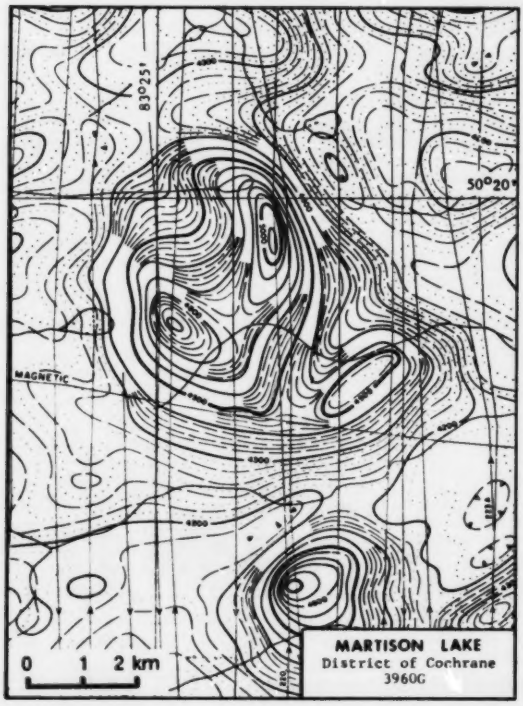

Figure 3. Aeromagnetic map of the Martison Lake anomalies (ODM-GSC 1967).

ECONOMIC GEOLOGY

Ferguson (1971) reported the presence of niobium and weathered titaniferous magnetite and phosphate in a magnetite sand.

Property Description

The following description of work completed during 1965 and 1966 (Figure 4) is taken from Ferguson (1971).

"Work jointly by Falconbridge Nickel Mines, Uranium Ridge Mines Ltd. and Matachewan Consolidated Mines Ltd. One hole drilled to investigate an airborne electromagnetic conductor superimposed on a magnetic anomaly. The hole was all in overburden with abundant magnetite in the sand from 358 feet to the end of the hole at 544 feet. Examination of the core from a boulder intersected at 358 feet, was considered to be that of a gossan overlying a carbonatite deposit and contained oxidized titaniferous magnetite and a hydrous basic phosphate probably from the breakdown of apatite, columbium [niobium] and strontium".

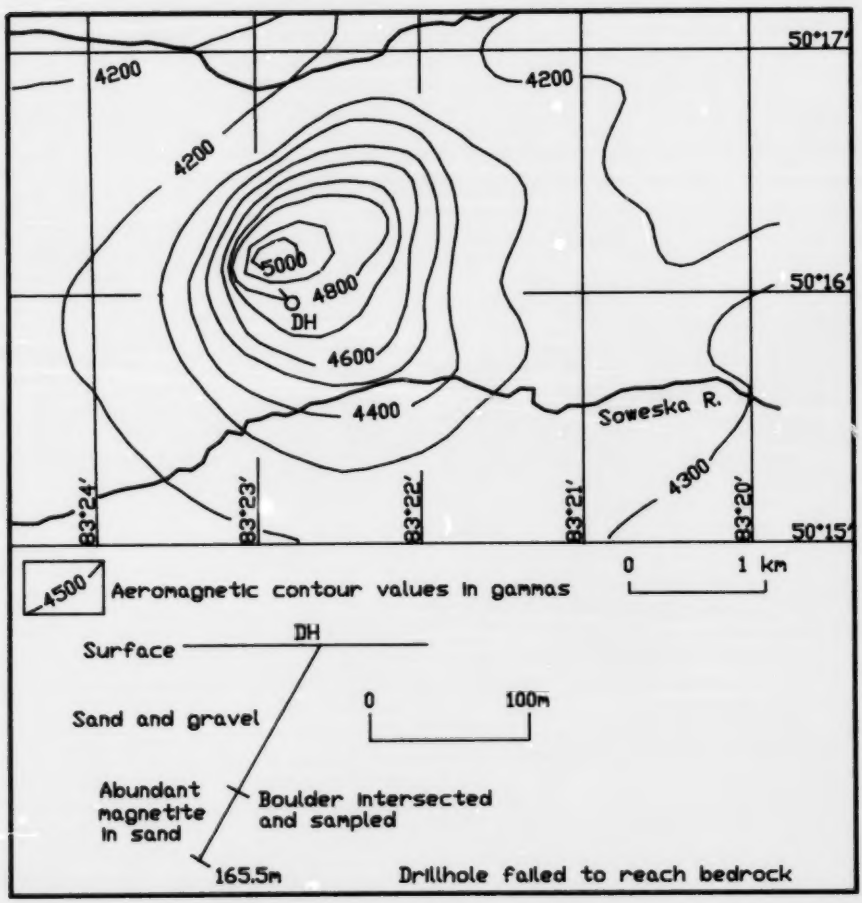

Figure 4. Sketch map of diamond drill hole completed on the Martison Lake anomalies (after Ferguson 1971).

Recommendations to the Prospector

The penetration of nearly 60 m of phosphorous-bearing magnetite sand without hitting solid rock suggests the presence of a residual accumulation on the weathered surface of a carbonatite (Figure 4). On the basis of this one drill hole it would appear that this anomaly presents a good target for a residual apatite deposit similar to the Cargill deposit located south of Kapuskasing, Ontario. The somewhat larger aeromagnetic anomaly to the north may represent a second carbonatite intrusion with similar potential.

NISKIBI LAKE ANOMALY

A prominent, elliptical, aeromagnetic anomaly is located near Latitude 56°00'N and Longitude 89°30'W (aeromagnetic map 3745G, ODM-GSC 1967) (Figure 5). This anomaly has a north-south axis of approximately 4.0 km and an east-west minimum width of 2.4 km. The aeromagnetic anomaly was interpreted by Satterly (1970) as a possible carbonatite intrusion. Its magnetic intensity and elliptical form are similar to the aeromagnetic pattern of several known carbonatite intrusions and thus the author concurs with Satterly's (1970) interpretation.

Approximately 96 km northeast of the anomaly the Aquitaine Sogepet et al. Pen No.1 well encountered Precambrian basement at 3351 feet (1005 m). Since the Niskibi Lake aeromagnetic anomaly is located closer than the drill hole to the onlap of the Paleozoic rocks onto Shield rocks, the anticipated depth to the target is likely less than 3351 feet. Considering the possibility of at least 2000 feet (600 m) of cover, the magnetic intensity of the anomaly presents an interesting target which likely contains a relatively high magnetite content.

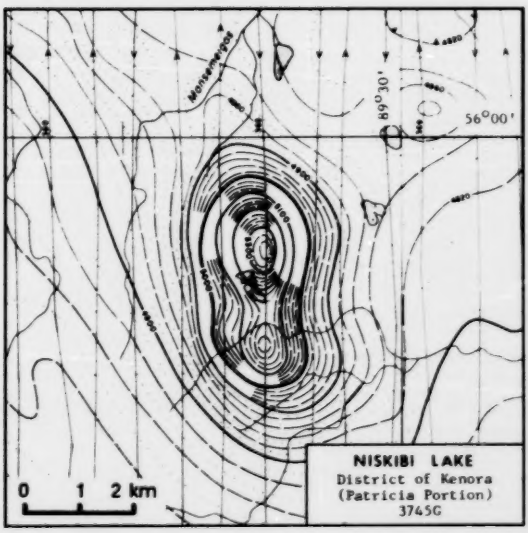

Figure 5. *Aeromagnetic map of the Niskibi Lake anomaly (ODM-GSC 1967).*

GOOSEBERRY BROOK ANOMALY

A strong circular aeromagnetic anomaly is located at approximately 55°15'N Latitude and 86°15'W Longitude (aeromagnetic maps 3843G, 3844G, ODM-GSC 1968) (Figure 6). The anomaly is 6.4 km in diameter. It has been interpreted by Satterly (1970) as a carbonatite intrusion. On the basis of form and magnetic intensity, the author concurs with the interpretation of Satterly (1970).

The nearest drill hole that reached the Precambrian basement is Aquitaine Sogepet et al. Pen No. 1, which is located 224 km northwest of the anomaly. At the well site, Precambrian basement was encountered at a depth of 3351 feet (1005 m). The Gooseberry Brook anomaly is approximately 96 km north of Precambrian outcrops of the Cape Henrietta Maria Arch and depth to the anomaly is likely much less than 1005 m.

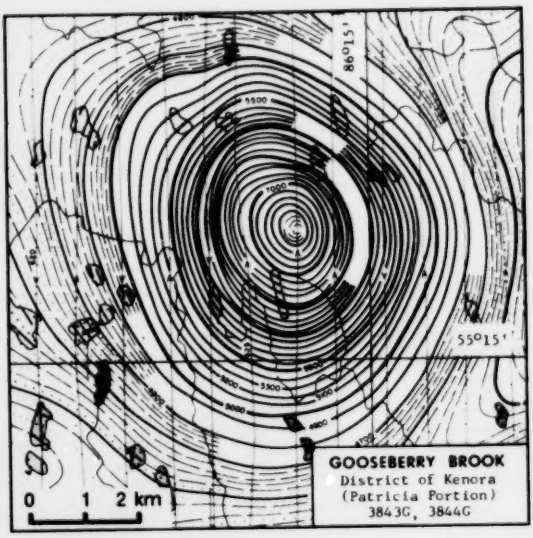

Figure 6. *Aeromagnetic map of the Gooseberry Brook anomaly (ODM-GSC 1968).*

LAWASHI RIVER ANOMALY

Near Latitude 52°50'N and Longitude 82°15'W, is a prominent circular anomaly (Figure 7) (aeromagnetic map 2298G, ODM-GSC 1964). The anomaly is 4.0 km in diameter and has been interpreted by Satterly (1970) as a carbonatite intrusion. Its circular pattern and relatively intense character is analogous to other known carbonatite intrusions within the Province, and the author concurs with Satterly's interpretation (1970). A drill hole at Puskwuche Point 140 km southeast of the anomaly encountered Precambrian basement rocks at a depth of 1529 feet (458.7 m). Since the anomaly is located much closer than the drill hole to Precambrian outcrops of the Cape Henrietta Maria Arch a thinner Paleozoic cover over the anomaly can be anticipated. Assuming that the interpretation of the anomaly is correct, mineralization typical of carbonatite intrusions can be expected.

POPLAR RIVER ANOMALY

Close to Latitude 51°40'N and Longitude 84°40'W, is a strong circular aeromagnetic anomaly (Figure 8), approximately 2.8 km in diameter (aeromagnetic map 3896, ODM-GSC 1967). The anomaly has been interpreted by Satterly (1970) as a carbonatite intrusion. The author concurs with Satterly (1970) on the basis of analogy with aeromagnetic patterns displayed by known carbonatite intrusions. At

the Albany Forks carbonatite complex, 64 km south of Poplar River, Keevil Mining Group Limited penetrated 734 feet (219 m) of Paleozoic cover before intersecting the carbonatite complex. Since the Poplar River anomaly lies north of the Albany Forks complex and closer to the Precambrian outcrops of the Cape Henrietta Maria Arch, thickness of the cover is not likely to be greater than at Albany Forks and perhaps is less. Assuming that the interpretation is correct, mineralization typical of carbonatite complexes could be anticipated.

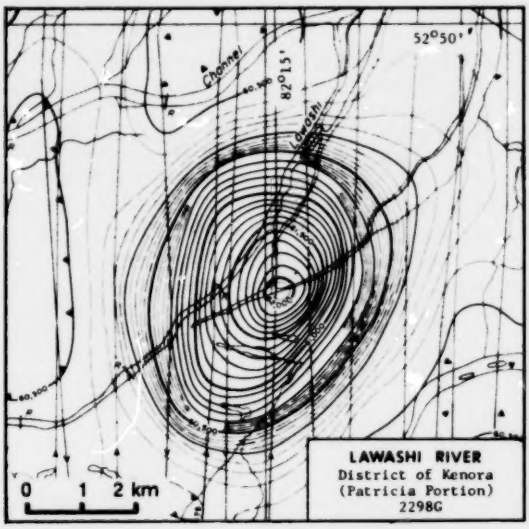

Figure 7. *Aeromagnetic map of the Lawashi River anomaly (ODM-GSC 1964).*

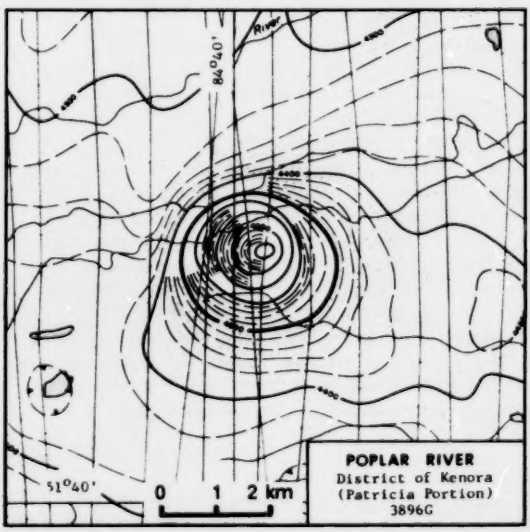

Figure 8. *Aeromagnetic map of the Poplar River anomaly (ODM-GSC 1967).*

LITTLE DROWNING RIVER ANOMALY

Approximately at Latitude 50°50'N and Longitude 84°55'W is a prominent aeromagnetic anomaly (Figure 9) approximately 1.6 km in diameter (aeromagnetic map 3893, ODM-GSC 1967). Satterly (1970) interpreted the anomaly as an alkalic rock - carbonatite intrusion. On the basis of other aeromagnetic patterns in the area, test-drilled by Keevil Mining Group Limited, the author would tend to interpret the anomaly as a gabbroic intrusion. However, the possibility of it being a carbonatite cannot be discounted. Drilling by Keevil on the Drowning River anomaly encountered Precambrian basement at a depth of approximately 810 feet (243 m) and a similar depth could be expected at Little Drowning River approximately 12 km south of the drill site.

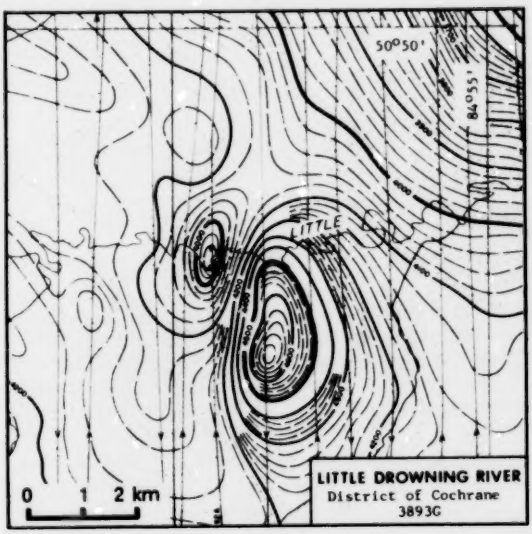

Figure 9. Aeromagnetic map of the Little Drowning River anomaly (ODM-GSC 1967).

KINGFISHER RIVER WEST ANOMALY

Near 50°45'N Latitude and 84°35'W Longitude is a crudely circular aeromagnetic anomaly (Figure 10) (aeromagnetic map 3892G, 3893G, ODM-GSC 1967). The anomaly is approximately 10 km in diameter and was interpreted by Satterly (1970) as an alkalic rock - carbonatite intrusion. On the basis of other aeromagnetic anomalies within the area, and limited drilling on these other anomalies, the author would interpret the Kingfisher River West anomaly as a mafic (gabbro) intrusion. The strong aeromagnetic anomaly displays the intensity of anomalies found above carbonatites but its large diameter is more typical of a gabbro or ultramafic intrusion. The possibility that the anomaly represents a carbonatite intrusion cannot be totally discounted.

Drilling by Keevil Mining Group Limited on the Drowning River anomaly approximately 19 km to the north encountered Precambrian basement rocks at a depth of 810 feet (243 m). A similar thickness can be anticipated at the Kingfisher River West anomaly.

In 1969, Keevil Mining Group Limited staked 90 claims covering the anomaly and completed a ground magnetic survey at a line spacing of 800 feet over portions of the anomaly (McLeod 1969). The anomaly was never drilled.

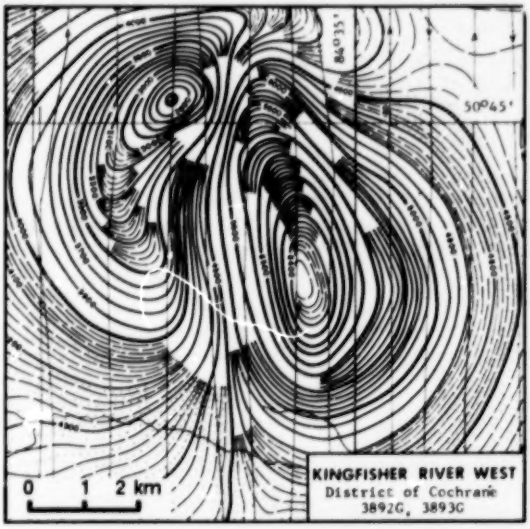

***Figure 10.** Aeromagnetic map of the Kingfisher River West anomaly (ODM-GSC 1967).*

KINGFISHER RIVER EAST ANOMALY

Approximately at Latitude 50°40'N and Longitude 84°25'W, is a tabular to curvilinear aeromagnetic anomaly (aeromagnetic map 3915G, ODM-GSC 1967) (Figure 11). The anomaly is approximately 12.8 km^2 in area and Satterly (1970) suggested that it might represent an alkalic rock - carbonatite intrusion. On the basis of other aeromagnetic anomalies in the area and the results of drilling by Keevil Mining Group Limited, the author would interpret the anomaly as a mafic intrusion.

At Drowning River, approximately 40 km northwest of the Kingfisher River East anomaly, Keevil Mining Group Limited penetrated 810 feet (243 m) of Paleozoic rocks before reaching Precambrian basement. A similar depth could be expected at the Kingfisher River East anomaly.

RECOMMENDATIONS FOR REGIONAL PROSPECTING

The James Bay Lowlands present a number of obstacles to exploration of these geophysical anomalies. The complexes are buried beneath younger Paleozoic rocks which are overlain by a generally wet, marshy muskeg. Roads are lacking in the region and lakes of sufficient size to land float-equipped aircraft are not abundant. Movement of equipment and personnel is expensive and often requires helicopters. Ground work can be conveniently done only in winter months using track-equipped vehicles.

On the basis of previous drilling within the lowlands, the soft, fractured nature of the overlying rocks inhibits or prevents drilling of inclined holes. Therefore, drill holes will provide only a limited evaluation of the economic potential of any given body. Internal structures within the alkalic intrusions are expected to be vertical to subvertical, thus the line of drill intersection would be parallel to the expected lithologies. Since zones of economic mineralization could be restricted to widths of only several tens of metres, a difficult problem exists in evaluating the economics of any given complex.

Since the identification of an ore deposit within an intrusion will depend on the number and closeness of sample points, it is imperative that engineers assigned to a drilling program make every effort to minimize time required for equipment movement, set-up, and penetration of overlying stratigraphy. The Paleozoic section is not likely to change significantly across any given intrusion, thus coring of more than one hole of this stratigraphy is unnecessary and expensive, and if the

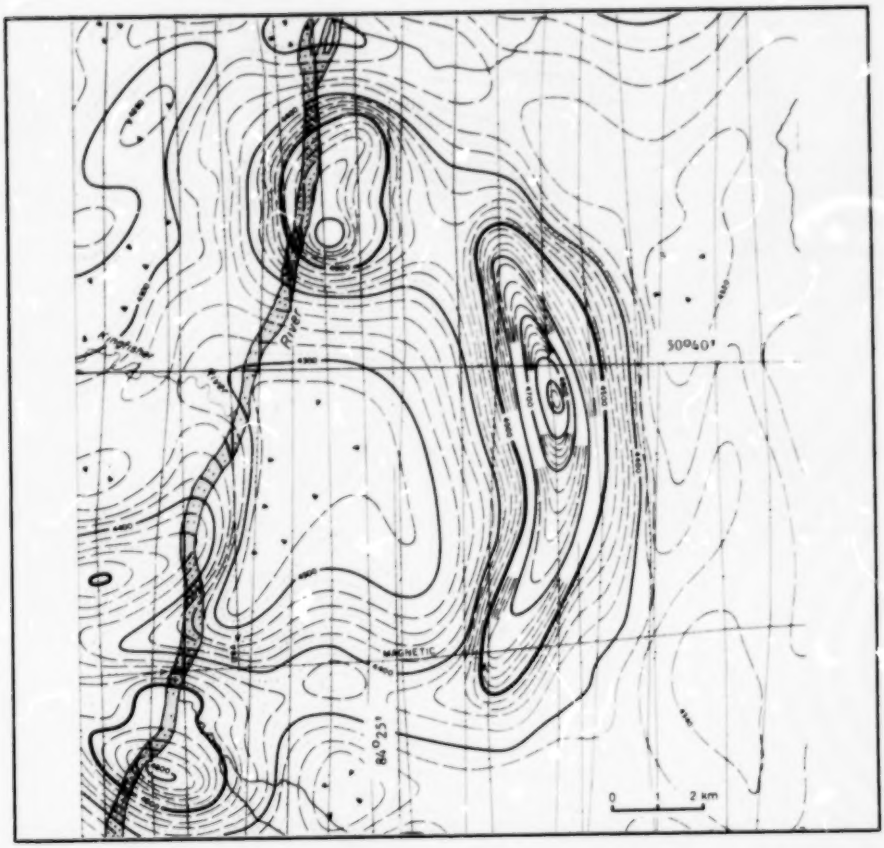

Figure 11. *Aeromagnetic map of the Kingfisher River East anomaly (ODM-GSC 1967).*

penetration rate can be improved, should be avoided. Since internal structures are likely almost vertical, there is no point in drilling more than about 30 m into fresh rock beneath any weathered rock capping. The success of a program would be dependent on maximizing the number of sample points for the money spent. Diamond drill core should be carefully preserved for study.

Undoubtedly the emplacement of the complexes was controlled by basement structures. At present, data is lacking to evaluate these structures. The clustering of a large number (nine) of these anomalies north of Hearst, Ontario, is particularly interesting.

The alkalic syenite intrusions may contain nepheline syenite, and low-grade magnetite deposits. The carbonatites are likely targets for magnetite, rare earths, uranium, phosphorous, niobium, and base metal mineralization. If the upper surfaces have been extensively weathered, then residual accumulations of apatite, pyrochlore and vermiculite may be present and probably of high grade.

The mafic intrusions (gabbro to ultramafic) are probably highly variable in lithology, and drilling of those bodies would be best directed towards the search for copper-nickel-platinum group mineralization. This mineralization is most likely to occur as disseminated sulphides interstitial to the rock-forming minerals. Generally speaking, carbonatite intrusions in Ontario are less than 6.5 km in diameter and give rise to a circular to elliptical, relatively intense, aeromagnetic anomaly.

The gabbro intrusions commonly display a crudely circular less intense aeromagnetic pattern of greater diameter than carbonatite intrusions.

The alkalic rock-syenite complexes are larger in size than the carbonatites and equivalent in size to the mafic bodies. The alkalic rock bodies commonly display a circular aeromagnetic pattern of concentric rings. The margins of these ring complexes may display a more intense magnetic signature than the cores, a pattern which reflects the common distribution of rock types from mafic rim to more felsic core. The mafic rocks generally contain more magnetite than the felsic rocks of the core.

The interpretation of rock type on the basis of aeromagnetic patterns is unreliable and a very poor substitute for a drill hole.

Anomalies Tested by Diamond Drilling

ALBANY FORKS CARBONATITE COMPLEX

The Albany Forks aeromagnetic anomaly was first shown on Federal-Provincial aeromagnetic surveys of the region (map 3894G, ODM-GSC 1967) (Figure 12). In 1969, Keevil Mining Group Limited completed a deep diamond drill hole on the anomaly and intersected a carbonatite intrusion. The drill hole indicated that the complex consists mainly of magnetite sovite; core lengths of up to 2.4 m of massive magnetite were intersected (the hole was drilled at a dip of 80°). Other minerals occur only in trace to minor amounts. The complex would appear likely to have economic potential as an iron deposit if it were not for its remote location and thick cover of Paleozoic rocks (731 feet, 279 m). Since the complex has been tested by only one drill hole, drilled at an angle which is probably subparallel to both banding and to widely varying compositional units within the complex, the complex remains largely untested. Work to date has only identified the cause of the aeromagnetic anomaly as a carbonatite intrusion. The intrusion warrants evaluation for its phosphate (apatite), niobium, uranium, rare earth element, vermiculite, and iron potential.

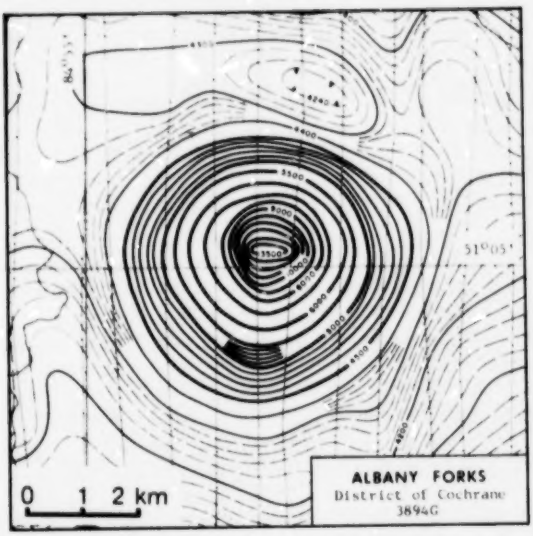

Figure 12. Aeromagnetic map of the Albany Forks Carbonatite Complex (ODM-GSC 1967).

Acknowledgment

Samples examined for this report were obtained from the Regional Geologist's Office, Ontario Ministry of Natural Resources, Timmins. The samples had been previously donated to the ministry by H.D. McLeod for Keevil Mining Group Limited.

Location and Access

The aeromagnetic anomaly covering the Albany Forks carbonatite complex is located at approximately 51°05'N Latitude and 84°50'W Longitude. The anomaly is located 172 km north of Hearst, Ontario, at a point 6 km west of the junction of the Albany and Kenogami Rivers. In summer, the site can be reached only by helicopter; in the winter the site can be reached by light ski-equipped aircraft which can land on a strip cut out of the swamps.

Physiography

McLeod (1969c) reported that the area in all directions is flat, wet muskeg with light timber cover, drained by scattered streams and creeks. There are no sizeable

lakes within 40 km of the complex and the nearest river large enough for use by float-equipped aircraft is approximately 16 km away (McLeod 1969c).

Laboratory Techniques

The most homogeneous specimens in the sample library of the Ontario Ministry of Natural Resources in Timmins were selected for thin sectioning. From this suite, a group was selected for complete rock analysis (see Appendix A).

Previous Work

Deines and Gold (1973) reported carbon and oxygen isotope compositions for the Albany Forks intrusion. The $\delta^{13}C$ values ranged from -3.1 to -5.3 ‰(PDB) and the $\delta^{18}O$ values ranged from 8.9 to 22.5 ‰(SMOW). Deines and Gold (1973) did not relate their isotopic data directly to the genesis of the Albany Forks carbonatite complex.

GENERAL GEOLOGY

The aeromagnetic anomaly of the Albany Forks intrusion is one of several within this region which displays a weak northwest trending isomagnetic contour pattern (Map P.578, ODM-GSC 1970). The Albany Forks aeromagnetic anomaly forms a prominent circular pattern which is smaller than most of the others of the area. The anomaly has a diameter of approximately 6.0 km and a surface area of approximately 25.0 km^2. The intrusion lies beneath approximately 220 m of Paleozoic sediment rocks, and has been penetrated by one diamond drill hole. Drilling has indicated a body of magnetite sovite containing magnetite units up to 2.4 m thick, measured along drill core (not true width). The age of the complex is unknown.

Magnetite Sovite

The dominant rock-type in samples is magnetite sovite. In hand specimen, the sovite is a fine-grained, grey to black, magnetite-rich carbonate rock.

In thin section the rock is fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. A few samples are inequigranular-seriate. In some magnetite-rich samples there are two grain sizes of magnetite, imparting a limited hiatal texture to the rock. The texture is transitional to hypidiomorphic because of the generally subhedral form of the coarse-grained magnetite. The mode is estimated to be 0 to 2 percent apatite, 10 to 50 percent magnetite, and 58 to 90 percent carbonate.

The apatite forms prismatic, subhedral to euhedral grains. It appears to be concentrated in bands and to be less abundant than in other sovitic rocks examined by the author. Several samples contain only traces or very small quantities of the mineral.

The magnetite can be subdivided into two types. One is coarse-grained anhedral to subhedral crystals, and the other is fine-grained dusty disseminations along carbonate grain boundaries. Rarely the finer-grained magnetite is enclosed within the carbonate grains. The coarser-grained magnetite occurs as single grains and as aggregates. Locally, this form of magnetite poikilitically contains subangular to rounded anhedral blebs of carbonate. The magnetite may cluster or aggregate into bands imparting a foliation to the rock. The fine-grained, dusty magnetite appears to be restricted to those samples containing in excess of 30 percent magnetite.

The carbonate forms an interlocking mosaic of anhedral grains and poikilitically enclosed grains within magnetite.

Traces of angular brown garnet were noted in several thin sections. The angular shape suggests that it may be xenocrystic.

Biotite-phlogopite forms very fine fibrous grains on the margins of magnetite grains and tiny tabular grains in association with magnetite. The biotite content is

rather low compared with sovite samples examined by the author from other complexes.

One sample contains very fine-grained patches of fibrous green amphibole. A very fine-grained brown mineral associated with the amphibole may be biotite.

Magnetite-Apatite Rock

One specimen appears to be a banded magnetite-apatite rock. The rock is estimated to contain 40 percent apatite, 55 percent magnetite, 5 percent carbonate and possibly traces of former olivine.

In one band, the apatite forms an equigranular, granoblastic, aggregate of grains interlocked with magnetite, and in another band it occurs as prismatic anhedral crystals interlocked with magnetite. Within the granoblastic apatite, a red-brown stain commonly appears along the apatite-apatite grain boundaries.

The magnetite occurs as anhedral to subhedral grains in both bands and in a few places encloses a small bleb of carbonate.

Carbonate, which is present only in the band with prismatic apatite, is anhedral and interstitial to the magnetite and apatite.

Possible former olivine is present in one band. Subrounded grains or areas have been completely altered to a red-brown mineral possibly iddingsite(?). The mineral occurs within the band containing the prismatic apatite.

The banding within this magnetite-apatite rock probably formed by cumulate settling within the carbonatite magma.

Magnetite Rock

One specimen of massive magnetite was examined in thin section. The texture is fine to medium grained, hiatal, hypidiomorphic. The modal composition is estimated to be 75 percent magnetite and 25 percent carbonate.

The magnetite occurs in two forms. The dominant form is fine to medium, anhedral to subhedral grains. The second form is fine-grained, dusty disseminations along carbonate grain boundaries and tiny inclusions within the carbonate grains.

The carbonate occurs as anhedral interstitial grains which locally enclose some fine-grained, dusty magnetite. X-ray diffraction analysis of the carbonate indicates that it is dolomite (Geoscience Laboratories, Ontario Geological Survey, Toronto).

Silicocarbonatite

One specimen of silicocarbonatite was examined in thin section. The core sample displays a brecciated structure formed by extensive veining by white carbonates. In thin section the texture of the rock is fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with serrate grain boundaries. The mode is estimated as phlogopite 80 percent, carbonate 17 percent, and magnetite 3 percent. Trace amounts of amphibole, barite, and apatite are present.

Phlogopite forms an interlocking mass of very fine- to fine-grained material. Some grains display bent and kinked (001) cleavage and some enclose very small opaque inclusions.

Subrounded, very fine-grained domains of phlogopite and magnetite are present. These domains are likely after a former but completely altered mafic mineral. The rounded form suggests former olivine.

The carbonate forms euhedral interstitial grains. The magnetite is very fine grained and appears to be closely associated with patches of very fine-grained phlogopite. It, along with the phlogopite, is likely a breakdown product of a former mafic mineral. Magnetite also is present in a linear streak suggesting that it filled a fracture.

Altered Gabbro

One specimen of homogeneous, equigranular, fine-grained, green rock was examined in thin section. The specimen is an altered gabbro and was noted in the drill logs of Keevil Mining Group Limited as a "basic dike(?)", approximately 4.2 m wide. The specimen could be from a xenolith or from a gabbroic (diabase) dike cutting the complex.

In thin section the rock is fine grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. The mode is estimated to be plagioclase (An_{4+}) 33 percent, carbonate 15 percent, biotite 25 percent, magnetite 15 percent, clinopyroxene 10 percent, amphibole 1 to 2 percent, apatite less than 1 percent, and chlorite 1 percent.

The plagioclase forms tabular anhedral to subhedral grains with spotty replacement by carbonate and saussurite.

The carbonate occurs as an alteration of the plagioclase and as anhedral interstitial grains.

Biotite forms irregular, angular red-brown grains, closely associated with magnetite. Magnetite may be interleaved with biotite. The biotite and magnetite are likely to have in part formed by pyroxene breakdown.

The magnetite forms subhedral to anhedral grains closely associated with biotite. Magnetite may be crudely skeletal and may occur as long needles up to 4 mm long.

Apatite forms euhedral prismatic crystals poikilitically enclosed in pyroxene, biotite, and magnetite.

The amphibole forms acicular pale green crystals, possibly after pyroxene. The amphibole is likely an actinolite-tremolite.

Clinopyroxene is anhedral to subhedral with turbid alteration along edges and cleavages. Irregular spotty alteration to biotite and magnetite is common along edges of grains. The clinopyroxene is interstitial to the plagioclase.

METAMORPHISM

The complex does not show evidence of having been regionally metamorphosed or recrystallized.

STRUCTURAL GEOLOGY

On the basis of thin section examination and descriptions of the core the magnetite sovite rock likely is banded. The banding is likely to display extreme compositional variation with magnetite and apatite being the dominant mineral variables. The possibility of pyroxene, pyrochlore, sulphide, or other mineral phases forming distinct bands in other areas of the intrusion is likely.

Some evidence of former brecciation is present.

The aeromagnetic pattern lacks any discontinuities which could be interpreted as faulting.

GEOPHYSICS

The complex was first apparent on Provincial-Federal aeromagnetic maps 3894G, P.578 (ODM-GSC 1967, 1970) which disclosed a circular aeromagnetic anomaly of approximately 5.6 km diameter.

Keevil Mining Group Limited completed a magnetometer survey over portions of the complex and identified an oval-shaped magnetic anomaly 2250 m wide (McLeod 1969c). The long axis of the anomaly trends northwest, perhaps reflecting the fault fracture controlling its emplacement. The ground magnetic anomaly is approximately 20,300 gammas above background (McLeod 1969c) and undoubtedly reflects the high magnetite content of the complex.

RECOMMENDATIONS FOR FUTURE STUDY

Relatively limited information on the complex's mineralogy is available from the sparse sampling of the complex. Future work on the body would necessitate obtaining additional samples. Microprobe analyses and an isotopic age determination are also needed.

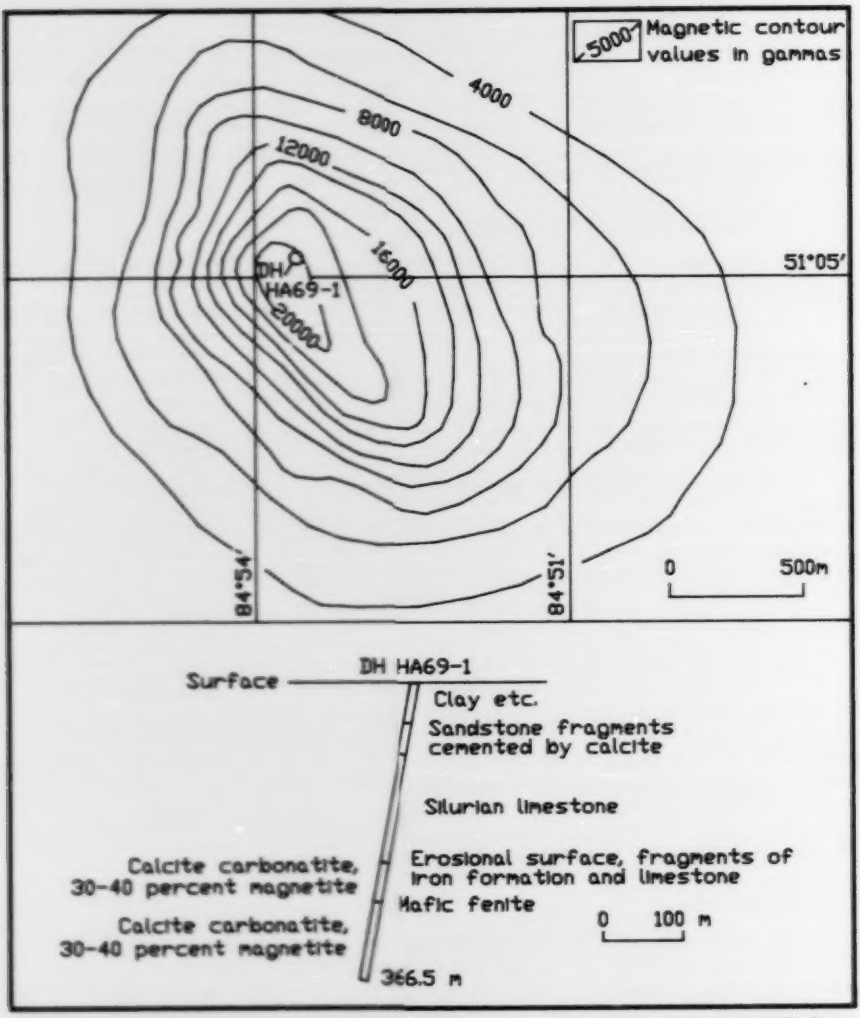

Figure 13. Sketch map of ground magnetic survey and diamond drill hole completed on the Albany Forks Carbonatite Complex (after Ferguson 1971).

ECONOMIC GEOLOGY

The aeromagnetic anomaly was staked by Keevil Mining Group Limited in 1968 and drilling has confirmed the presence of a magnetite-rich carbonatite complex. The complex is essentially untested and offers potential for any of the various mineral commodities commonly associated with this type of intrusion. McLeod (1969c) suggested the presence of pyrochlore but this mineral was not observed in thin section by the author. A selected magnetite-rich core sample from 860.0 feet gave

37.8 percent total iron, 450 ppm Nb, 60 ppm Ti, 30 ppm Sc, 15 ppm Y, and 7 ppm Yb (Geoscience Laboratories, Ontario Geological Survey, Toronto). Cerium, La, Nd, and Eu were not detected (limit of detection 100 ppm).

Property Description

Keevil Mining Group Limited staked a total of 31 claims in 1968 and 1969 to cover the airborne-indicated magnetic anomaly (Figure 12). The company completed a ground magnetometer survey along the claim lines and completed one diamond drill hole to a depth of 1203 feet (360.5 m) (Figure 13). This hole encountered a carbonatite intrusion at a depth of 731 feet. The carbonatite contains abundant magnetite with some massive sections up to 2.4 m wide. The hole was drilled at 80 degrees to the horizontal and considering that the internal structures within the complex are likely vertical to subvertical, all drill intersections give greatly exaggerated widths to the limited lithologies encountered.

Recommendations to the Prospector

Considering that the complex has been tested by only one drill hole at an angle of 80 degrees into a body likely to display both vertical to subvertical structures and lithologic inhomogeneity, the only valid comment is to say the body is untested. The body could host niobium, uranium, phosphate, vermiculite, and rare earth mineralization. Even though it is difficult to evaluate the rather high magnetite content, it would undoubtedly be the subject of investigation if the body were in a less remote position and not buried beneath Paleozoic cover. If another mineral of economic value could be found, and if the high magnetite content is consistent, the magnetite would likely add to the cash flow of any mining operation.

Even though work on this body will be difficult and expensive the body remains untested and can be considered to be a potential host to the type of mineralization typical of this rock suite. Additional drilling of this anomaly should check the Paleozoic-Precambrian unconformity for possible residual accumulation of apatite, pyrochlore or vermiculite.

DROWNING RIVER MAFIC COMPLEX

The Drowning River complex lies beneath a cover of Paleozoic sedimentary rocks 154 km northwest of Hearst, Ontario. It straddles the Drowning River at a point 13 km to the west of its junction with the Kenogami River. The complex has been tested by one diamond drill hole by Keevil Mining Group Limited. The drill hole encountered andesinite. The lower portion of the core appears sheared suggesting post-emplacement deformation. The age of the complex is unknown and mineralization was not encountered. On the basis of this one sample point, a mafic rock intrusion is interpreted to be the cause of the aeromagnetic anomaly. Such a complex could host disseminated sulphide mineralization.

Acknowledgment

The core examined in this study was obtained from the Regional Geologist's Office, Ontario Ministry of Natural Resources, Timmins. The core samples had previously been donated to the ministry by H.D. McLeod for the Keevil Mining Group Limited.

Location and Access

The aeromagnetic anomaly that indicates the intrusion beneath the Paleozoic cover is centered at approximately 50°53'N Latitude and 84°15'W Longitude (Figure 14). The complex can be reached by landing float-equipped aircraft on the Drowning River but this is dangerous even under the best of conditions. The rivers are shallow, making equipment movement difficult, and during the summer the rivers and streams are too shallow for normal boat travel. The easiest and simplest access is by helicopter. Extended operations in the area may necessitate the

building of a winter road and the restricting of operations to the winter months when equipment movement is easier.

Previous Work

The anomaly had not been investigated prior to the work by Keevil Mining Group Limited and no additional work has been attempted.

Physiography

The ground is generally flat, wooded, and dotted with marshes.

Laboratory Techniques

A suite of thin sections was prepared from the most homogeneous core sections remaining. Select samples were submitted for complete rock analysis (see Appendix B).

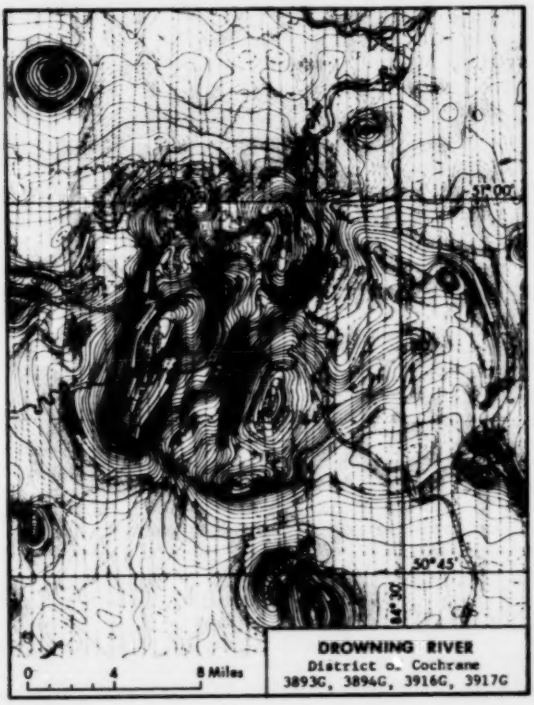

Figure 14. Aeromagnetic map of the Drowning River anomaly (ODM-GSC 1967).

GENERAL GEOLOGY

The Drowning River mafic complex is indicated by a crudely circular aeromagnetic anomaly with a diameter of approximately 38 km (Figure 14) (aeromagnetic maps 3893G, 3894G, 3916G, 3917G, ODM-GSC 1967). The anomaly has a surface area of approximately 289 km^2. The complex has been tested by one hole drilled at 75 degrees to a depth of 1160.0 feet (438.0 m). This hole penetrated 825 feet (247.5 m) of Paleozoic sedimentary rocks consisting of limestone, sandstone, and dolomite. The limestone section was soft, had a tendency to wash-out, and prevented testing of the anomaly until the third attempt. The rock encountered was an andesinite and lacked any evidence of mineralization.

Andesinite

The andesinite samples from the upper portion of the drill hole display well-developed primary textures, however those samples from the lower section show evidence of shearing, recrystallization, and potassium and silica metasomatism. The age of the complex is uncertain; the author has observed primary igneous textures in similar rocks ranging from Archean to late Proterozoic in age. The age appears irrelevant to the economic potential of the complex since copper, nickel, and platinum group element mineralization is not restricted to any one age group of intrusions.

In thin section andesinite is seen to be fine to medium grained, equigranular to inequigranular-seriate, protoclastic, allotriomorphic with straight to curved grain boundaries.

The mode is estimated to be plagioclase (An_{30-41}) 89-99 percent, biotite 0 to 4 percent, and opaques 0 to 7 percent. Trace amounts of clinopyroxene and olivine are present. Accessory and alteration minerals include apatite, chlorite, saussurite, carbonate, iddingsite, myrmekite, clinozoisite, and an unidentifiable brown stain.

The plagioclase occurs as blocky to tabular crystals, generally fresh with light flecks of saussurite alteration. The albite twin lamellae are often bent or fractured imparting a protoclastic texture to the rock. The best-developed protoclastic texture is restricted to the larger plagioclase grains. Some of the plagioclase grains have diffuse patches where albite twinning appears as faint vestiges.

The biotite occurs as brown to red-brown, anhedral, interstitial grains and as very fine-grained, fibrous-appearing aggregates which commonly enclose magnetite. The fine-grained biotite appears to be largely a breakdown product of a former mafic mineral while the larger grains appear to be primary late-stage grains.

On the basis of reflected-light examination, the opaque is likely magnetite. Where associated with very fine-grained biotite, it and the biotite are likely breakdown products of a former mafic mineral. Some of the magnetite may be primary in origin.

The trace to very minor quantities of clinopyroxene are anhedral, interstitial, colourless and are altered to amphibole(?), very fine-grained biotite, and an unidentified brown stain.

The trace olivine occurs as round anhedral grains largely altered to iddingsite and possibly to minor talc and chlorite. Opaques (magnetite) occur along curved cracks within the former olivine. Only one sample contains traces of fresh olivine.

Minor amounts of interstitial myrmekite are present in one sample. Chlorite is a minor alteration product of biotite. Minor carbonate is interstitial, possibly situated along fractures.

The sheared recrystallized samples from the bottom section of the hole have a granoblastic texture.

These altered rocks contain up to 40 percent string perthite with traces of microcline. The perthite is fractured, stressed and flecked with saussurite. In some altered zones the perthite is present as ill-defined turbid patches that lack perthitic development.

Quartz is present as interstitial, anhedral, generally unstrained grains. The plagioclase is more sodic in composition than the plagioclase in the normal andesinite. The former mafic minerals of these recrystallized rocks have been altered to biotite, opaques, carbonate, chlorite, clinozoisite, and sericite.

Petrographically the rock is classified as an olivine-clinopyroxene andesinite.

Dike Rocks

Within the area of deformed gabbro, several dikes of granite are noted in diamond drill logs of Keevil Mining Group Limited. The dikes were described as occurring within reddened and altered gabbro. The author obtained one sample of this granite from the core library of the Ministry of Natural Resources' regional office in Timmins.

In thin section the rock is fine to medium grained, massive, inequigranular-seriate, allotriomorphic with curved to straight grain boundaries. The mode is estimated to be perthite 40 percent, quartz ±10 percent, and plagioclase (An_{29-31}) 50 percent. Traces of opaques chlorite, sericite, and possibly clinozoisite are present.

The alkalic feldspar is string or banded perthite; some grains display the quadrille twinning of microcline. The feldspar is anhedral and appears stressed. It is sometimes fractured with a turbid alteration at stress points. Carlsbad twinning is common and uncommonly rounded blebs of quartz are poikilitically enclosed.

The quartz is anhedral, clear, unstrained, and interstitial.

Plagioclase occurs as anhedral, clear grains which display a weak protoclastic texture due to slight fracturing and bending of albite twin planes.

The diamond drill logs of Keevil Mining Group Limited indicate that chilling of the dike margins was not observed. This leucocratic dike rock is classified as quartz monzonite and texturally is aplitic.

The author has observed granitic diking of mafic intrusive rocks within the Archean but not within the gabbroic rocks of the Proterozoic. Therefore, this intrusion may be much older than some of the others within the same area.

METAMORPHISM

The upper portion of the core displays an unmetamorphosed allotriomorphic texture. The lower portion of the core appears granoblastic and has been subjected to the introduction of quartz and microcline perthite. The author believes that metamorphism and metasomatism resulted from metasomatism along a shear zone and not from a regional metamorphic event. Diamond drill logs of Keevil Mining Group Limited indicate that the bottom 140 feet of the hole has been subjected to alteration.

STRUCTURAL GEOLOGY

The Drowning River mafic complex is one of several intrusive complexes which lie beneath Paleozoic cover of the James Bay Lowlands and whose presence has been inferred on the basis of aeromagnetic data. This series of aeromagnetic anomalies has a roughly west-of-north trend (ODM-GSC 1970), implying structural control, however there is insufficient data to speculate on its nature.

GEOPHYSICS

The Drowning River complex is indicated on aeromagnetic maps 3893G, 3894G, 3916G, and 3917G (ODM-GSC 1967). These maps indicate a terrain with a background intensity of about 4,000 to 4,500 gammas. The complex is indicated by both high and low magnetic responses which in combination display a crudely circular aeromagnetic pattern, but individually display an east-of-north strike. The drill hole completed by Keevil Mining Group Limited tested an aeromagnetic low of 220 gammas while an aeromagnetic high of 7,100 gammas 6.4 km east of the low was not tested. The high plagioclase and low magnetite content of the andesinite readily accounts for the low aeromagnetic response of the area tested.

The company completed a ground magnetometer survey over a small portion of the complex covering the area of low aeromagnetic intensity. This survey encountered minimum readings 3,300 gammas below the highest reading obtained in the survey and the company estimated the lowest reading to be 4,000 gammas below base level magnetic intensity for the area.

The contoured magnetic pattern displays an east-of-north trend of 10 to 20 degrees (McLeod 1969a).

RECOMMENDATIONS FOR FUTURE STUDY

An isotopic age for the complex would be useful for modelling of the regional geology, and more detailed mineralogical studies are also desirable. The limited number of samples available prevents any detailed study of the body. Geologic studies of the body must await additional drilling for sample material.

ECONOMIC GEOLOGY

The one drill hole completed by Keevil Mining Group Limited failed to intersect mineralization. At present, the complex is not known to contain mineralization.

Property Description

In 1968 Keevil Mining Group Limited staked 41 claims covering portions of the Drowning River aeromagnetic anomaly. Nine claims were dropped in 1969 (McLeod 1969). The company cut 32.8 km of line along which a magnetometer survey was completed (Figure 15) using a Sharpe Fluxgate Model M.F.1 magnetometer.

The company drilled three holes before they were successful in penetrating the Paleozoic cover. The company selected a long linear magnetic anomaly to test in hopes that it represented a carbonatite intrusion. The first two attempts were abandoned because the soft limestone washed out, causing the drill rods to break (McLeod 1969a). The third hole intersected the andesinite at 825 feet and reached a final depth of 1160 feet. The drill holes failed to encounter mineralization and work was terminated.

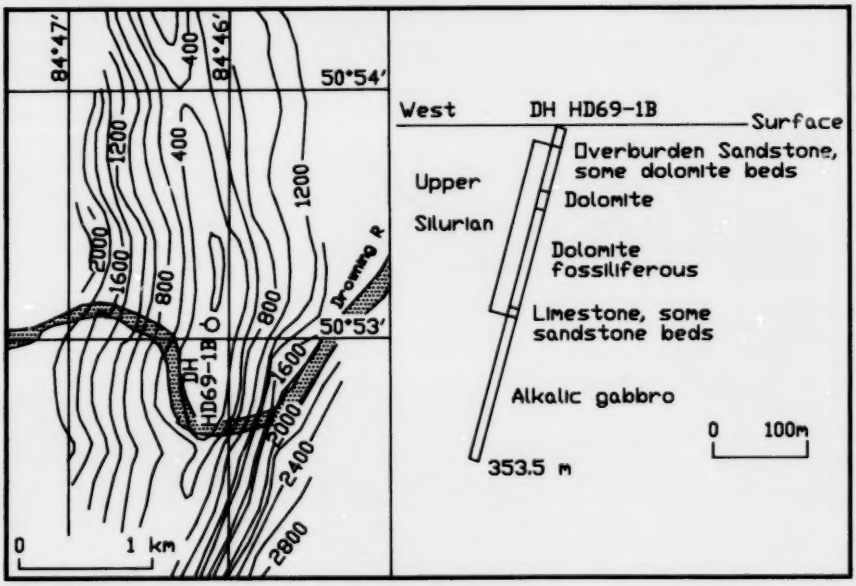

Figure 15. *Sketch map of ground magnetic survey and diamond drill hole completed on the Drowning River mafic complex (after Ferguson 1971).*

Recommendations to the Prospector

Making suggestions as to the economic potential of a complex 38 km in diameter, on the basis of a single core sample 1.25 cm in diameter, is not possible. One must assume that the one drill hole has correctly identified the source of the Drowning River aeromagnetic anomaly as a mafic intrusion of possible gabbroic composition. One may also assume that the presence of such plagioclase-rich rocks encoun-

tered in the one drill hole implies that various cumulate processes may have been operative during emplacement. If the above two assumptions are correct, then some phases of the body may contain accumulations of sulphides of potential economic interest. Those sulphides likely to be present could potentially host copper, nickel and platinum group metal mineralization. Because of the nature of the overlying Paleozoic rocks, the location of the intrusion, and its large size, testing is likely to be difficult and expensive.

MAMMAMATTAWA MAFIC COMPLEX

The Mammamattawa intrusion lies beneath 875 feet (268.5 m) of Paleozoic rocks. The presence of the intrusive complex was originally indicated on aeromagnetic maps 3914G and P.578 (ODM-GSC 1967, 1970) (Figure 16). The body was tested by one drill hole, completed by Keevil Mining Group Limited. This hole encountered gabbroic intrusive rock. The body may have potential for disseminated sulphide deposits within some of its phases even though the one completed hole encountered no sulphides. Samples of this complex were unavailable for study.

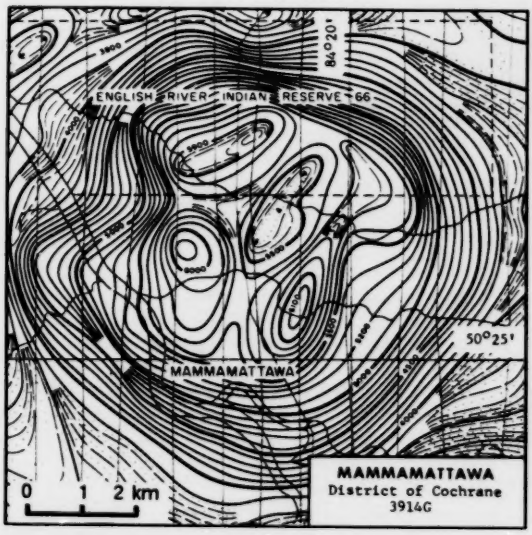

Figure 16. Aeromagnetic map of the Mammamattawa mafic complex (ODM-GSC 1967).

Location and Access

The intrusion is located at approximately 50°26'N Latitude and 84°20'W Longitude. Aircraft can land on the Kenogami River which lies immediately west of the claims.

Physiography

The area consists of wet muskeg with some timber along rivers and creeks (McLeod 1967d). McLeod (1967d) stated that while summer operations are possible, winter operations would be easier.

GENERAL GEOLOGY

The intrusive complex is indicated by an aeromagnetic anomaly of approximately 8.0 km diameter (Figure 16). The anomaly has a surface area of approximately 50 km^2. The complex has been tested by one diamond drill hole which intersected anorthosite (McLeod 1969d). No mineralization has been found.

STRUCTURAL GEOLOGY

Structures such as banding were not reported from the core (McLeod 1969d).

The aeromagnetic pattern lacks discontinuities which could be interpreted as faulting. The aeromagnetic anomaly is one of several within the region which have a crude northwest trend. The structural control of the emplacement for these intrusions is unknown.

GEOPHYSICS

The complex was initially identified by Provincial-Federal aeromagnetic surveys (ODM-GSC 1967, 1970) which disclosed the intrusive body beneath the Paleozoic rocks.

Keevil Mining Group Limited completed a ground magnetometer survey over the aeromagnetic anomaly at 900 m line-spacing (McLeod 1969d). This survey was conducted with a Fluxgate Model M.F.1 magnetometer. The survey indicated three positive areas and a circular magnetic low (McLeod 1969d). The magnetic low is 2300 gammas lower than the high and the one hole completed was drilled within this low (McLeod 1969d). McLeod (1969d) reported that the hole encountered anorthosite.

ECONOMIC GEOLOGY

A complex 8.0 km in diameter intersected by one drill hole cannot be considered to have been tested adequately. The presence of anorthosite indicates a mafic intrusion and the anorthosite phase, possibly of cumulate origin, is likely only one rock type of many. The identification of the aeromagnetic anomaly as a mafic intrusion suggests a possibility that disseminated sulphides of copper, nickel, and the platinum group metals may be present in possible cumulate phases of the intrusion.

Property Description

Keevil Mining Group Limited staked 65 claims in 1967 covering a large aeromagnetic anomaly. The company chained and picketed five baselines and completed a ground magnetometer survey on pace and compass lines at 900 m spacing (McLeod 1969d). The company completed one drill hole at 80 degrees to the horizontal to a depth of 935.0 feet. This hole penetrated 185.0 feet of overburden, 710 feet of Paleozoic siltstone, limestone, sandstone, and dolomite (Diamond Drill Logs, Report 10, Assessment Files Research Office, Ontario Geological Survey, Toronto).

Altered mafic intrusive rocks were encountered at 895.0 feet and fresh mafic intrusive rocks at 908.5 feet (Diamond Drill Logs, Report 10, Assessment Files Research Office). The hole was completed to a depth of 935.0 feet and mineralization was not intersected (McLeod 1969d).

Recommendations to the Prospector

It is impossible to evaluate an intrusion of this size on the basis of one drill hole. One must assume that the anorthosite encountered in the drill hole is indicative of a mafic intrusion and that the anorthosite is likely only one phase of the body. The rock types implied to be present could be considered favourable for the presence of disseminated copper, nickel and platinum group metal mineralization.

SQUIRREL RIVER MAFIC COMPLEX

The Squirrel River complex lies beneath Paleozoic cover rocks at a depth of 800 to 1000 feet. The aeromagnetic anomaly lies approximately 76 km northwest of Hearst, Ontario. The complex was identified by Federal-Provincial aeromagnetic surveys (maps 3914G, P.578, ODM-GSC 1967, 1970) (Figure 17) and was staked by the Keevil Mining Group Limited in 1969. The company completed a ground magnetic survey over portions of the aeromagnetic anomaly and diamond drilled

two areas of high magnetic intensity separated by a region of relatively low magnetic intensity. The drilling penetrated the Paleozoic cover and encountered gabbroic rocks. No mineralization was encountered. On the basis of the two sample points the anomaly is caused by a mafic rock complex which could host disseminated sulphide mineralization.

Acknowledgment

The samples examined came from the Regional Geologist's Office, Ontario Ministry of Natural Resources, Timmins. The samples had been previously donated to the ministry by H.D. McLeod of the Keevil Mining Group Limited.

Location and Access

The complex is located 76 km north of Hearst, Ontario, and 14 km southeast of Mammamattawa Post at the junction of the Kenogami and Nagagami Rivers. The complex is located at approximately 50°20'N Latitude and 84°13'W Longitude. The complex can be reached by helicopter, or by canoe or boat during summer months.

Field Methods

The complex is completely covered by Paleozoic rocks and sampling is thus restricted to diamond drill core samples preserved at the Regional Geologist's Office, Timmins, Ontario.

Previous Work

The only previous geological work is that completed by the Keevil Mining Group Limited. This work consisted of line cutting, ground magnetometer surveys, and two diamond drill holes through the Paleozoic cover.

Figure 17. Aeromagnetic map of the Squirrel River mafic complex (ODM-GSC 1967).

Physiography

The area is covered by swamp and muskeg, making summer operations difficult.

Laboratory Techniques

Core samples displaying the least alteration and greatest homogeneity were thin sectioned, and those that were also fresh and unaltered in thin section were selected for complete rock analysis (see Appendix C).

GENERAL GEOLOGY

The Squirrel River Complex is indicated on aeromagnetic map 3914G (ODM-GSC 1967) to be approximately 9.6 km in diameter and have a surface area of approximately 72 km^2. A portion of the inferred complex was covered by a ground magnetometer survey and two sites of higher magnetic intensity were selected for diamond drill testing. The Paleozoic cover was penetrated at the two sites and core consisting of picrite and gabbro was recovered. The complex is likely a layered mafic intrusion. All samples examined for this report, except one, came from hole No. 1, the most northwesterly of the two.

Picrite to Gabbro

In thin section the rock is fine to medium grained, massive, equigranular, protoclastic, allotriomorphic, with curved to straight grain boundaries. Where the plagioclase has subhedral to almost euhedral outlines, the texture approaches hypidiomorphic.

The sample from hole No. 2 has a glomeroporphyritic texture resulting from clustering of plagioclase grains. The mode for these rocks is estimated as 5 to 30 percent olivine, 0 to 15 percent clinopyroxene, 55 to 81 percent plagioclase (An_{42-59}), 1 to 5 percent biotite, 4 to 5 percent magnetite, and 1 to 5 percent apatite.

The olivine occurs as rounded anhedral grains with moderate to high relief and curved fractures. The olivine locally occurs poikilitically in pyroxene and rarely, itself encloses apatite crystals. The olivine shows traces of alteration to chlorite and/or biotite.

The clinopyroxene is colourless, anhedral, interstitial and in places encloses apatite, olivine, plagioclase, and small grains of magnetite. The specimen from hole No. 2 contains pyroxene with a schiller structure defined by two sets of tiny tabular opaque inclusions.

The inclusions in clinopyroxene grains are oriented in two directions, at approximately 60 to 80 degrees to each other. The sample from hole No. 2 is more mafic than samples from hole No. 1 and contains an estimated 30 percent clinopyroxene.

Plagioclase forms blocky to tabular grains, anhedral to subhedral in form, which locally have a protoclastic texture defined by bending and fracturing of albite twin planes. The protoclastic texture is best developed in the larger grains. In one sample, several plagioclase grains are concentrically zoned. Minor spotting of saussuritic alteration may be present. The plagioclase occurs in circular clots up to 5 mm in diameter in the glomeroporphyritic sample. In sympathetic relationship with the increased clinopyroxene content in this sample, the plagioclase content is lower, estimated at approximately 50 percent.

The biotite occurs as brown to red-brown, fine to medium grains that in large part formed by breakdown of the other mafic minerals. It commonly forms very fine-grained narrow rims completely enclosing magnetite grains. It also may form large, optically continuous grains, ragged in outline, which poikilitically enclose magnetite, apatite, olivine, and clinopyroxene. The larger grains are likely primary but late in the petrogenetic sequence.

The magnetite occurs as anhedral grains commonly with narrow rims of very fine-grained biotite. The magnetite occurs as interstitial grains to plagioclase, olivine, and pyroxene, and as very tiny grains enclosed in pyroxene.

Apatite forms subhedral to euhedral prismatic crystals. It occurs poikilitically in all minerals except plagioclase and uncommonly in olivine. Actinolite in very fine-grained fibrous clots in one sample, and chlorite and epidote in others, occur as breakdown products of the other mafic minerals. They are present in quantities estimated to be less than 1 percent.

Petrographically the complex is highly variable in composition, consisting of picrite, olivine gabbro, and anorthositic olivine gabbro.

METAMORPHISM

The rock has a well developed igneous texture and is unmetamorphosed. The very minor alteration may be a product of late-stage deuteric or autometamorphic processes rather than a reflection of an independent metamorphic event.

STRUCTURAL GEOLOGY

The Squirrel River aeromagnetic anomaly is one of several in the same general region of the James Bay Lowlands. These anomalies are crudely aligned along a northwest trend indicating that their emplacement was controlled by a major structural zone (ODM-GSC 1970). The wide variation in modes between thin sections suggests to the author that the complex is likely a layered complex.

GEOPHYSICS

The complex has been covered by Federal Provincial aeromagnetic surveys which have outlined its roughly circular form (ODM-GSC 1967, 1970).

The Keevil Mining Group Limited completed a ground magnetometer survey over portions of the complex using a Sharpe Fluxgate Model M.F.1 magnetometer (McLeod 1969b). The ground survey identified two anomalies, one of 4500 gammas and a second of 1800 gammas above background (McLeod 1969b). The highs may be actually higher since the ground survey was not extensive enough to establish the regional background value. Diamond drilling indicated that the anomalies are caused by the presence of 4 to 5 percent magnetite in the gabbroic rocks.

RECOMMENDATIONS FOR FUTURE STUDY

An isotopic age determination and microprobe analyses of the major mineral phases are highly desirable. It would appear that additional work on this complex is dependent on the completion of additional exploration which would make samples available for study.

ECONOMIC GEOLOGY

To evaluate a mafic intrusive complex with a surface area of approximately 72 km^2 on the basis of two diamond drill holes, cutting core of approximately 1.5 cm in diameter, is impossible. On the basis of these two holes, one might expect that the mafic body is a layered intrusion which could potentially contain disseminated copper, nickel, and platinum group metals in sulphide-bearing lithologic units.

Property Description

In December 1967, the Keevil Mining Group Limited staked 122 contiguous claims, later reduced to 60 in 1969 (McLeod 1969b).

The company completed a grid, on 240 m spacing, and a ground magnetometer survey over portions of the complex (McLeod 1969b) (Figure 18). This work outlined two areas of magnetic relief which were subsequently drill tested.

Diamond drill hole HSGS-1 was completed on the northwesterly site and reached a total depth of 1450 feet. The hole encountered altered (weathered?) gabbro at 989.7 feet and fresh gabbro at 1023.5 feet. The hole failed to intersect mineralization and the magnetic anomaly is ascribed to the minor magnetite content of the gabbro.

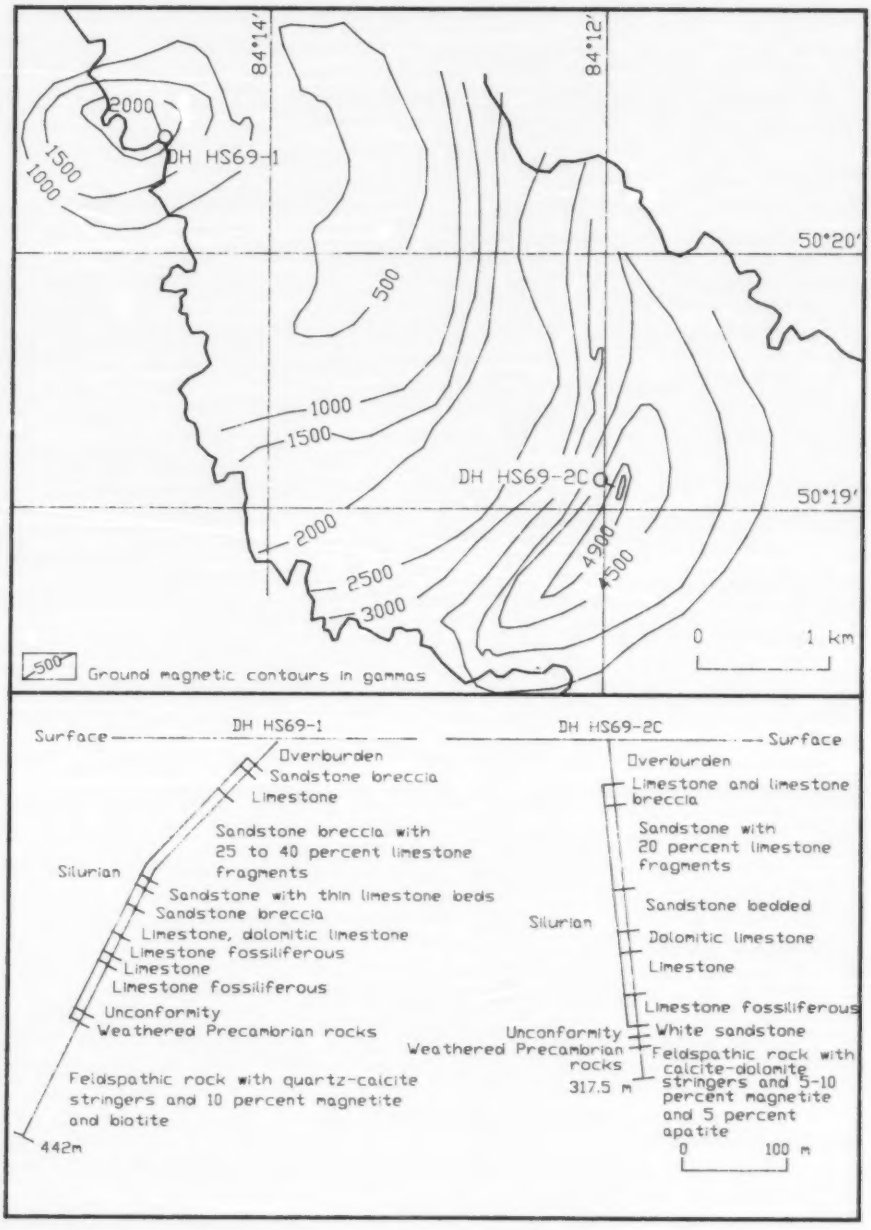

Figure 18. *Sketch map of ground magnetic survey and two diamond drill holes completed on the Squirrel River mafic complex (after Ferguson 1971).*

On the southeasterly site, four attempts were made to penetrate the Paleozoic section. The first two attempts at inclined holes (50°) failed and the third attempt at 65° also failed. The successful fourth hole was drilled at 83°. Altered (weathered?) rock was encountered at 875.5 feet and fresh rock at 924.5 feet. The hole was completed to a depth of 1042 feet; the rock was described as fine-grained and similar to the rock intersected in hole No. 1.

The anomaly is caused by minor accessory magnetite and mineralization was not intersected. A total of 2102 feet was drilled before completion of the fourth hole to the target. Difficulties in completing the hole were attributed to softness of and brecciation within the Paleozoic section.

Recommendations to the Prospector

On the basis of the data available a recommendation as to exploration potential is pure speculation. On the basis of the samples examined by the author the complex could potentially host accumulations of disseminated sulphides of potential economic interest. Considering the interpreted size of the body, a large volume of material could be available. In view of the difficulty of exploration and development, anyone considering work on the complex must anticipate relatively high expenses.

Appendix A

Petrographic Descriptions and Chemical Analyses of Samples from the Albany Forks Carbonatite Complex.

TABLE A–1. PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM THE ALBANY FORKS CARBONATITE COMPLEX.

Note: Samples are from diamond drill hole HA69-1, drilled by the Keevil Mining Group Limited. The sample numbers denote the depth, in feet, of the core samples.

Sample HA69-1-760'
Magnetite sovite
(no chemical analysis)

Fine grained, massive, equigranular, allotriomorphic with curved to straight grain boundaries. Apatite forms subhedral, prismatic crystals in very minor amounts. Magnetite is anhedral to subhedral, may enclose small irregular blebs of carbonate. Magnetite grains occur in diffuse clots and aggregates of grains. Biotite forms fibrous grains or aggregates and very small, brown to reddish-brown grains in association with magnetite. Anhedral carbonate grains form an interlocking mosaic. The drill core is moderately to weakly banded due to variation in magnetite content.

Sample HA69-1-771'
Magnetite sovite

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic with curved to straight grain boundaries. Anhedral carbonate grains form an interlocking mosaic. Magnetite occurs as anhedral disseminated grains, in poorly defined clots and bands. Possible garnet occurs in trace amounts; it is turbid, dull to pale brown in colour, and may partially enclose magnetite. Amphibole occurs as a very fine grained fibrous aggregate of pale green needles. Amphibole occurs in patches and scattered irregularly throughout. Traces of a reddish-brown mineral with amphibole may be biotite. Traces of apatite are present. The core is banded, due to variation in magnetite content.

Sample HA69-1-831'
Magnetite sovite

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Apatite forms elongated, subhedral, prismatic grains, which appear to be concentrated in a band. Garnet forms angular reddish-brown grains, possibly xenocrystic. Both garnet and biotite occur in trace amounts. Traces of biotite occur on margins of some apatite grains. Magnetite forms anhedral to subhedral grains, and enclose rounded to angular blebs of carbonate. Anhedral carbonate grains form an interlocking mosaic.

Sample HA69-1-886'
Metasomatized gabbro xenolith

Fine grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Carbonate is present as anhedral interstitial grains. Biotite forms reddish-brown, irregular, angular grains; closely associated with magnetite. A very fine-grained brown mineral is possibly biotite after pyroxene. Magnetite occurs interleaved with biotite, crudely skeletal in elongated crystals up to 4 mm long and as narrow rims on altering pyroxene. Apatite forms euhedral prismatic crystals poikilitic in pyroxene, biotite, and magnetite. Amphibole occurs as needle-like grains of very pale green colour, possibly after pyroxene. Amphibole is very fine grained. Clinopyroxene is anhedral to subhedral with turbid alteration along edges and cleavages, irregular spotty alteration along edges of grains. Clinopyroxene is interstitial to plagioclase (An_{47}), which forms tabular, anhedral to subhedral grains with spotty replacement by carbonate and saussurite. Some patches of very fine

grained, pale green chlorite occur in one area of the thin section. Chlorite is possibly after pyroxene.

Sample HA69-1-1000'
Magnetite sovite

Fine grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Magnetite is anhedral, disseminated throughout with traces of brown biotite. Anhedral grains of carbonate form an interlocking mosaic. The drill core is weakly banded due to slight variation in magnetite and carbonate content.

Sample HA69-1-1120'
Magnetite sovite

Fine to medium grained, massive, inequigranular, allotriomorphic with curved to straight grain boundaries. Magnetite forms anhedral to subhedral grains with abundant inclusions of angular to rounded carbonate. Fine-grained magnetite occurs poikilitically in carbonate and along grain boundaries. Anhedral carbonate grains form an interlocking mosaic.

TABLE A-2. MAJOR ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE ALBANY FORKS CARBONATITE COMPLEX

	Altered Gabbro	Magnetite Sovite			
Sample No.	HA69-1 886	HA69-1 771	HA69-1 831	HA69-1 1000	HA69-1 1120
SiO_2	44.6	1.27	0.86	1.59	1.71
Al_2O_3	16.5	2.92	2.79	2.41	1.66
Fe_2O_3	4.41	10.1	2.83	2.95	12.1
FeO	8.45	6.14	5.68	4.84	11.1
MgO	4.85	13.0	14.6	14.3	11.1
CaO	6.25	25.5	27.6	28.0	20.6
Na_2O	4.30	0.26	0.19	0.30	0.22
K_2O	2.42	0.02	0.04	0.06	0.08
TiO_2	3.25	0.03	0.00	0.00	0.00
P_2O_5	0.72	3.84	2.16	4.28	1.26
S	0.16	<0.01	0.40	0.07	0.70
MnO	0.17	0.46	0.71	0.64	0.64
CO_2	1.66	36.6	42.8	40.4	32.9
H_2O^+	1.34	0.09	0.05	0.11	0.07
H_2O^-	0.82	0.50	0.40	0.46	0.52

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

TABLE A-3. TRACE ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE ALBANY FORKS CARBONATITE COMPLEX

	Altered Gabbro	Magnetite Sovite			
Sample No.	HA69-1 886	HA69-1 771	HA69-1 831	HA69-1 1000	HA69-1 1120
Ag	<1	2	<1	<1	2
Au					
As					
Ba	1460	1020	280	320	380
Be	3	3	<1	1	<1
Bi					
Co	34	13	13	7	28
Cr	<5	22	6	8	21
Cu	41	7	8	8	13
Ga	18	3	1	1	3
Hg					
Li	35	4	5	4	7
Mn					
Mo	<10	<10	<10	<10	
Nb	100	3400	300	900	200
Ni	16	<5	<5	<5	<5
Pb	<10	<10	<10	<10	<10
Rb	40	<10	<10	<10	<10
Sb					
Sc	15	40	30	20	20
Sn	5	13	2	3	11
Sr	670	3385	5740	6345	3845
Ti					
V					
Y	40	40	40	40	<10
Zn	150	155	465	98	405
Zr					
La	<100	200	200	200	<100
Nd	<300	<300	<300	<300	<300
Ce	210	330	300	330	190
Eu	<100	<100	<100	<100	<100
Yb	4	5	4	2	2

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Appendix B

Petrographic Descriptions and Chemical Analyses of Samples from the Drowning River Mafic Complex.

TABLE B–1. PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM THE DROWNING RIVER MAFIC COMPLEX

Note: Samples are from diamond drill hole HD69-1, drilled by the Keevil Mining Group Limited. The sample numbers denote the depth, in feet, of the core samples.

Sample HD69-1-825'
Andesinite

Fine to medium grained, massive, equigranular, protoclastic, allotriomorphic, with curved to straight grain boundaries. Magnetite is anhedral and interstitial. Minor biotite forms very fine grains and occurs as isolated small tabular grains on magnetite. Traces of minor interstitial chlorite are present. Clinopyroxene forms small grains, which are interstitial and altered to a brown mineral, in part biotite. Anhedral, stubby to tabular grains of plagioclase (An_{36-41}) form an interlocking aggregate. Some plagioclase grains are bent and fractured.

Sample HD69-1-840'
Andesinite

Fine to medium grained, massive, inequigranular, protoclastic, allotriomorphic with curved to straight grain boundaries. Thin fractures are filled with brown alteration and carbonate. Minor reddish-brown, interstitial, ragged biotite. Very minor opaques, possibly magnetite. Plagioclase (An_{30-37}) forms blocky to tabular grains, generally clear with flecks of saussurite along grain boundaries and fractures. Locally, albite twinning is only a faint vestige. Larger grains display bent twin lamellae.

Sample HD69-1-862'
Andesinite

Fine to medium grained, massive, equigranular, protoclastic, allotriomorphic, with curved to straight grain boundaries. Plagioclase (An_{39-40}) forms anhedral, stubby to tabular grains with bent twin lamellae and fractured grains. Turbid interstitial carbonate is a minor component. Traces of interstitial chlorite and scattered flecks of saussurite are present.

Sample HD69-1-920'
Olivine-bearing andesinite

Fine to medium grained, massive, equigranular, allotriomorphic, protoclastic, with straight to curved grain boundaries. Plagioclase (An_{30-37}) forms anhedral, fresh, blocky to tabular crystals, with bent twin lamellae. Minor olivine forms rounded grains altered to iddingsite, talc, serpentine(?), and magnetite; fresh olivine is rare. Magnetite occurs along rims and curved fractures of former olivine grains. Biotite forms small reddish-brown, anhedral interstitial grains. Disseminated interstitial magnetite is a minor accessory. Some skeletal magnetite occurs after olivine. Traces of clinopyroxene are partially altered to very fine-grained amphibole and biotite.

Sample HD69-1-1035'
Pyroxene-bearing andesinite.

Fine to medium grained, massive, equigranular, allotriomorphic, protoclastic, with curved to embayed grain boundaries. The rock may be mildly metamorphosed. Traces of interstitial myrmekite are present. Iddingsite, possibly after olivine, is reddish-brown in colour; some grains are rimmed with clinozoisite and in other places magnetite. Clinopyroxene forms anhedral, colourless grains with incipient alteration to biotite. Plagioclase (An_{32-35}) forms anhedral blocky crystals with bent albite twin lamellae. Local patches only have vestiges of albite twinning. Flecks of saussurite (?) are present. Grain boundaries are embayed.

Sample HD69-1-1070'
Quartz monzonite (dike)

Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Quartz forms anhedral, unstrained, clear interstitial grains. Perthite is present as a stringy microcline perthite. Grains are fractured and display turbid alteration along fractures. Perthite is flecked with saussurite and altered areas do not display well developed twinning. Carlsbad twinning is present. Rare rounded grains of quartz may be enclosed by perthite. Plagioclase (An_{29-31}) occurs as anhedral, clear and somewhat protoclastic grains. Plagioclase is fractured and displays bent twin lamellae. The sample contains trace to minor amounts of opaques, chlorite, sericite, and clinozoisite. It may be a dike rock.

TABLE B-2. MAJOR ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE DROWNING RIVER MAFIC COMPLEX

	Andesinite					Quartz Monzonite
Sample No.	HD69-1 825	HD69-1 840	HD69-1 862	HD69-1 920*	HD69-1 1035**	HD69-1 1070***
SiO_2	50.3	53.3	56.0	50.0	53.7	66.0
Al_2O_3	32.1	29.6	27.4	22.9	30.7	20.0
Fe_2O_3	0.83	0.80	0.14	3.72	0.09	1.06
FeO	1.38	1.15	1.00	5.07	0.84	1.38
MgO	0.85	0.50	0.59	2.18	0.43	0.23
CaO	6.70	6.95	6.43	7.67	5.50	0.87
Na_2O	6.16	6.21	6.55	5.05	6.56	3.60
K_2O	0.96	0.93	1.31	0.70	1.99	5.43
TiO_2	0.40	0.39	0.24	1.70	0.16	0.23
P_2O_5	0.06	0.07	0.05	0.06	0.10	0.02
S	0.22	0.21	0.05	0.20	0.06	0.07
MnO	0.01	0.01	0.01	0.08	0.01	0.02
CO_2	0.32	0.33	0.24	0.92	0.39	0.43
H_2O^+	0.22	0.05	0.21	0.20	0.10	0.02
H_2O^-	0.36	0.45	0.46	0.54	0.52	0.46

Notes:
* Olivine-bearing andesinite.
** Pyroxene-bearing andesinite.
***Quartz monzonite dike.
For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

TABLE B-3. TRACE ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE DROWNING RIVER MAFIC COMPLEX

	Andesinite					Quartz Monzonite
Sample No.	HD69-1 825	HD69-1 840	HD69-1 862	HD69-1 920*	HD69-1 1035**	HD69-1 1070***
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	1140	1200	1500	820	1280	140
Be	3	<1	<1	1	<1	3
Bi						
Co	12	13	6	32	7	<5
Cr	<5	<5	<5	<5	<5	<5
Cu	26	14	8	18	11	8
Ga	15	16	17	15	16	17
Hg						
Li	4	5	11	4	7	4
Mn						
Mo	<10	<10	<10	<10	<10	<10
Nb	<30	<30	<30	200	<30	70
Ni	<5	<5	<5	<5	<5	<5
Pb	<10	<10	<10	<10	<10	<10
Rb	<10	<10	<10	<10	10	100
Sb						
Sc	<5	<5	<5	<5	<5	<5
Sn	<1	<1	<1	2	<1	<1
Sr	380	2090	2090	1540	1315	45
Ti						
V						
Y	<10	<10	<10	100	<10	30
Zn	28	18	16	80	18	37
Zr						
La	<100	<100	<100	<100	<100	100
Nd	<300	<300	<300	<300	<300	<300
Ce	<10	<10	10	20	20	350
Eu	<100	<100	<100	<100	<100	<100
Yb	<1	<1	<1	30	<1	2

Notes:
* Olivine-bearing andesinite.
** Pyroxene-bearing andesinite.
***Quartz monzonite dike.
For sample descriptions, see Table B-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Appendix C

Petrographic Descriptions and Chemical Analyses of Samples from the Squirrel River Mafic Complex.

TABLE C–1. PETROGRAPHIC DESCRIPTIONS OF SAMPLES FROM THE SQUIRREL RIVER MAFIC COMPLEX

Note: Samples are from diamond drill holes HS69-1 and HS69-2, drilled by the Keevil Mining Group Limited. The sample numbers denote the depth, in feet, of the core samples.

Sample HS69-1-1075'
Olivine gabbro

Fine to medium grained, equigranular, allotriomorphic, with curved to straight boundaries. Olivine forms rounded anhedral grains with traces of biotite or chlorite on the edges of some grains. Olivine locally is poikilitic in clinopyroxene. Clinopyroxene is anhedral, interstitial and may enclose apatite and olivine. Apatite is euhedral to subhedral, and prismatic; it is commonly poikilitic in biotite, magnetite, pyroxene. Biotite forms brown ragged grains generally enclosing magnetite. Magnetite is anhedral, and interstitial to olivine and pyroxene, commonly rimmed with very fine grained biotite. Plagioclase (An_{42-50}) forms blocky to tabular anhedral crystals with rare weakly bent albite twin planes.

Sample HS69-1-1125'
Anorthositic olivine gabbro

Fine to medium grained, massive, equigranular to inequigranular-seriate, hypidiomorphic. Apatite forms euhedral, prismatic crystals poikilitic in olivine, clinopyroxene, and magnetite. Magnetite is anhedral, interstitial to plagioclase, olivine, and clinopyroxene. Biotite forms small isolated ragged grains and occurs as small fibrous coronas or rims on magnetite. Biotite is reddish-brown in colour. In one area of the thin section, biotite is extensively altered to chlorite. Clinopyroxene is colourless to very pale green, interstitial, and poikilitically encloses plagioclase, olivine, apatite, and magnetite. Plagioclase (An_{50-54}) forms tabular crystals, lightly saussuritized. Larger crystals may display weak bending of twin plane. Olivine forms round anhedral grains poikilitic in interstitial pyroxene. Olivine is relatively fresh and unaltered.

Sample HS69-1-1159'
Picrite

Fine to medium grained, massive, equigranular, protoclastic, hypidiomorphic. Plagioclase (An_{44-59}) forms a subhedral tabular interlocking network of crystals. Some crystals are broken and some albite twin lamellae are bent. Apatite is euhedral, prismatic, and poikilitic in olivine, clinopyroxene, and magnetite. Biotite forms large ragged grains, brown to reddish-brown in colour enclosing apatite and olivine. Locally, it forms large grains with inclusions of apatite and olivine. Biotite has a sieve texture and gives the impression of being after former pyroxene. Magnetite is interstitial to olivine and invariably enclosed in biotite. Magnetite and biotite may be breakdown products of pyroxene. Olivine forms round anhedral grains and may enclose apatite crystals. It is generally fresh but in places displays traces of iddingsite alteration. Traces of epidote are present.

Sample HS69-1-1225'
Clinopyroxene-bearing picrite

Fine to medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Apatite forms euhedral to subhedral prismatic grains poikilitic in clinopyroxene and olivine. Clinopyroxene is colourless, anhedral, and locally encloses olivine and apatite. Biotite forms large ragged, optically continuous grains which enclose clinopyroxene, olivine and apatite. Magnetite is anhedral and interstitial to olivine and pyroxene. Magnetite in places engulfs apatite, pyroxene,

and olivine. It may also have a narrow rim of very fine grained biotite. Olivine forms round anhedral grains which locally have curved cracks. Olivine is poikilitic in clinopyroxene. Plagioclase (An_{38-44}) forms blocky to tabular grains, which show minor fracturing, rare bent twin lamellae, and rare concentric zoning. The texture appears weakly protoclastic.

Sample HS69-1-1400'
Clinopyroxene-bearing picrite

Fine to medium grained, massive, weakly protoclastic, allotriomorphic, with curved to straight grain boundaries. Apatite forms euhedral to subhedral prismatic crystals poikilitic in clinopyroxene and olivine. Biotite forms anhedral, ragged, large, optically continuous grains which envelop magnetite, apatite, olivine and clinopyroxene. Magnetite is anhedral, and interstitial to olivine and clinopyroxene. Grains may have narrow rims of very fine-grained biotite. Minor actinolite occurs as fibrous aggregates of crystals possibly from clinopyroxene and olivine breakdown. Clinopyroxene forms colourless, anhedral grains which locally enclose apatite and olivine. Olivine forms anhedral rounded grains with curved fractures. Plagioclase (An_{42-55}) occurs as anhedral, blocky to tabular crystals with rare bending of albite twin planes.

Sample HS69-2-1000'
Olivine gabbro

Fine to medium grained, massive, glomeroporphyritic, with curved to straight grain boundaries. Clinopyroxene is colourless, anhedral, with schiller structures defined by opaque inclusions oriented in two directions at an acute angle of approximately 60 degrees in elongated grain, displaying prominent prismatic cleavage. Apatite forms euhedral crystals poikilitic in clinopyroxene. Olivine occurs as anhedral grains with curved fractures and in one instance appears interstitial to pyroxene. Magnetite is anhedral, interstitial, and commonly rimmed with fine grained brown biotite. Small grains of magnetite may occur poikilitic in pyroxene. Biotite generally forms fine-grained rims enclosing magnetite. Plagioclase (An_{46}-) is anhedral, forms blocky to tabular crystals, and commonly occurs in aggregates. Plagioclase is fresh, and large grains display well bent albite twin lamellae. One grain contains a poikilitic olivine grain.

TABLE C-2. MAJOR ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE SQUIRREL RIVER MAFIC COMPLEX

Sample No.	HS69-1 1075	HS69-1 1125	HS69-1 1159	HS69-1 1225	HS69-1 1400	HS69-2 1000
SiO_2	37.7	26.2	37.6	35.7	36.2	36.2
Al_2O_3	15.4	7.40	17.3	15.4	15.1	12.6
Fe_2O_3	4.70	9.90	4.70	4.70	5.00	4.40
FeO	14.1	22.0	13.0	15.4	14.1	17.5
MgO	6.57	10.9	6.12	6.87	6.75	6.24
CaO	9.38	8.10	8.82	9.15	8.85	10.9
Na_2O	2.73	0.98	3.31	2.52	2.77	1.97
K_2O	0.79	0.46	0.83	0.86	0.90	0.52
TiO_2	3.66	5.30	3.46	4.13	3.99	5.48
P_2O_5	2.67	4.06	2.58	3.19	2.81	2.70
S	0.11	0.07	0.07	0.10	0.10	0.32
MnO	0.24	0.41	0.24	0.27	0.23	0.27
CO_2	0.76	1.77	1.03	0.93	1.46	0.11
H_2O^+	0.32	0.80	1.18	0.21	0.59	0.39
H_2O^-	0.46	0.49	0.44	0.40	0.40	0.24

Notes:
Sample HS69-1 1075 - Olivine gabbro
Sample HS69-1 1125 - Anorthositic olivine gabbro
Sample HS69-1 1159 - Picrite
Sample HS69-1 1225 - Clinopyroxene-bearing picrite
Sample HS69-1 1400 - Clinopyroxene-bearing picrite
Sample HS69-2 1000 - Olivine gabbro
For sample descriptions see Table C-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto:

TABLE C-3. TRACE ELEMENT ANALYSES OF WHOLE-ROCK SAMPLES FROM THE SQUIRREL RIVER MAFIC COMPLEX

Sample No.	HS69-1 1075	HS69-1 1125	HS69-1 1159	HS69-1 1225	HS69-1 1400	HS69-2 1000
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	660	360	850	630	750	630
Be	2	2	2	2	2	4
Bi						
Co	59	97	56	55	63	60
Cr	19	40	18	18	20	6
Cu	88	133	40	66	43	110
Ga	13	10	11	10	14	14
Hg						
Li	6	12	12	5	7	4
Mn						
Mo	<10	<10	<10	<10	<10	<10
Nb	40	40	35	40	50	30
Ni	41	78	36	37	41	5
Pb	<10	<10	<10	<10	<10	<10
Rb	10	10	10	20	20	<10
Sb						
Sc	10	7	9	10	7	40
Sn	4	5	2	3	3	3
Sr	820	850	810	835	790	1995
Ti						
V						
Y	30	40	30	35	35	40
Zn	170	265	170	190	190	190
Zr						
La	<100	<100	<100	<100	<100	<100
Nd	<300	<300	<300	<300	<300	<300
Ce	210	300	200	220	230	180
Eu	<100	<100	<100	<100	<100	<100
Yb	3	5	2	3	3	3

Notes:
Sample HS69-1 1075 - Olivine gabbro
Sample HS69-1 1125 - Anorthositic olivine gabbro
Sample HS69-1 1159 - Picrite
Sample HS69-1 1225 - Clinopyroxene-bearing picrite
Sample HS69-1 1400 - Clinopyroxene-bearing picrite
Sample HS69-2 1000 - Olivine gabbro
For sample descriptions, see Table C-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

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